Oxygen-Enriched Coal Combustion with Carbon Dioxide Recycle and Recovery: Simulation and Experimental Study

Author: John M. Veranth
Student: Gautham Krishnamoorthy
Institution: University of Utah, Department of Chemical and Fuels Engineering
Address: 1495 East 100 South 109 KENN B, Salt Lake City, UT 84112-1114
Telephone: 801-581-3789
Fax: 801-581-5607
Email: John.Veranth@m.cc.utah.edu
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Abstract

Carbon dioxide recovery for sequestration or beneficial use can be achieved either by post combustion gas separation or by the use of oxygen enriched feed. This study examines the option of coal combustion using oxygen feed with carbon dioxide recycle to control the adiabatic flame temperature. Current computational modeling capabilities are being applied to build on the pioneering studies of O_2 feed / CO_2 recycle combustion found in the literature. The simulations are using an existing state-of-the-art 3-dimensional computer code for turbulent reacting flows with reacting particles. The objectives are to better define the areas where additional data are needed to accurately model these unconventional combustion conditions, and to develop a detailed plan for a future pilot-scale experimental study.

The GLACIER code developed by Reaction Engineering International is being used to conduct computational studies of the primary furnace section of a coal fired boiler. A simulation was set up that will allow comparison of new model output to the extensive experimental data from an Argonne National Laboratory pilot scale study (Abele, 1987) (Payne, 1987). The current computational model studies continue to support earlier results which indicated that oxygen-enriched combustion is technically and economically feasible compared to alternative CO_2 control processes. A ratio of (C02+H20)/02 of 2.66 gives similar burning rates and wall heat transfer to that observed in conventional combustion.
A better understanding of the differences between conventional pulverized coal combustion and combustion in an oxygen/recycled CO_2 atmosphere will be needed to design commercial-scale technology demonstrations. The expected differences include changes in char burnout, toxic metal partitioning, ash deposition, NOx chemistry, and radiation heat transfer.

The formation of submicron ash was identified as an area where CO2 recycle may cause changes that have operational and design consequences. Submicron ash is formed by a process involving reduction of metal oxides in the coal minerals under a CO-rich atmosphere on the surface of the burning char, vaporization of the resulting metal or suboxide, diffusion away from the char particle, reoxidation of the metal, and particle formation by nucleation and surface growth. A recent study of submicron particle formation coupled with computational simulation of particle trajectories and furnace conditions (Lee, 2000) used a model of the vaporization process (Quann, 1982) that does not properly calculate the CO/CO2 ratio on the char surface. Kinetics and thermodynamic data for an improved metal vaporization

model has been determined from the literature, preliminary calculations have been performed, and code development of a subroutine for incorporation into a metal vaporization post-processor model is planned. Comparisons of model predictions for metal vaporization and submicron ash formation in a boiler will be made of predicted metal vaporization for air and for oxygen/recycle gas coal combustion.

List of Publications

None to date. A publication on the metal vaporization work is planned.

List of Students Receiving Support.

Gautham Krishnamoorthy, Ph.D. Candidate, Department of Chemical and Fuels Engineering, University of Utah.

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